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Director
Advanced Research Projects Agency
Washington, D. C.

Attention: Dr. Glen Finch

Subject: Semi-annual Technical Report of Research under Contract No. F44620-67-C-0099 for the period 1 August 1967 to 31 December 1967 - Sponsored by Advanced Research Projects Agency ARPA Order No. 966

Dear Sir:

Enclosed is a progress report of research activities under subject contract for the period 1 August 1967 to 31 December 1967.

Very truly yours,

Michael I. Posner
Assoc. Prof., Psychology
Acting Principal Investigator

MIP: mh
Enclosures

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SEMI-ANNUAL TECHNICAL REPORT OF RESEARCH
UNDER CONTRACT NO. F44620-67-C-0099
FOR THE PERIOD
1 AUGUST 1967 TO 31 DECEMBER 1967

CODING SYSTEMS IN PERCEPTION AND COGNITION

During the first six months of the contract, we have been engaged in gathering together the strands of a number of different projects funded by a variety of government agencies. These include the Air Force Office of Scientific Research, the National Institute of Health, the National Science Foundation, and the Graduate School of the University of Oregon. Because this is the first technical report under our new project, we cite papers in a number of instances which were begun and in a few cases completed prior to the start of the contract. This has been done in an effort to give an integrated picture of the present course and direction of our research effort.

The main theme of our research during the first six months has been an exploration of the different qualities of coding systems which might represent processing of information from external (perceptual) and internal (memorial) stimuli. Taking our cues from the major senses, we have been concerned with visual, auditory, and kinesthetic codes. The identification of coding systems with different sense modalities breaks down as we examine the utilization of information which is abstracted from separate sensory experiences. We have provided evidence on the efficiency of such abstraction and are pursuing some of its functional characteristics.

In addition to seeking the main qualities of coding systems, we have begun to look at their modifiability over time. This general approach might be characterized as trying to seek the constraints which govern the transformation or mapping of information from one coding system to another. These constraints include the rate of information transfer, the permissable directions of transfer between coding systems, the number of simultaneous transformations and so on. The breadth of research underlying these general questions might best be considered if the topics being pursued by each of our research teams are taken separately.

I. PERCEPTION AND PSYCHOPHYSICS

Fagot is directing a research program emphasizing the psychophysics of prothetic (quantitative) dimensions. In a paper written during the course of the contract, (Fagot & Stewart, 1967) it was shown that the most accurate form of the generalized magnitude estimation law for the psychophysical function brightness is $\Psi = \Phi^n - \Phi_0^n$. This indicates that the threshold correction should be made based on the psychological rather than the physical scale. It is, therefore, necessary to correct the brightness of the stimulus at all levels by a constant brightness rather than correcting it by a constant physical luminence.

Psychophysical procedures provide a method of relatively controlled investigation for observing the quantitative properties of simple stimulus dimensions. Fagot and Stewart have recently completed a series of investigations which consider the role of practice in the modification of the performance in psychophysical situations. In these situations subjects are given feedback about the accuracy with which they bisect the difference in intensity between two standard light sources. Since there is a strong tendency for psychophysical scales to be concave downward, the psychological bisection judgments generally tend to be too low on the physical scale. By feedback, the bisections come to approximate the actual physical value of the correct middle intensity. Moreover, since the consistency of the judgments increase, precise empirical analysis of individual scales is possible. The subjects are then transferred to new bisection problems and the investigators seek to determine whether the corrections induced by feedback act upon the actual perception of the brightness of these stimuli or, whether it merely allows the subject to correct his motor performance in setting the value of the particular stimulus combination with which he has had practice. Since these experiments await analysis, it is not yet certain whether or not the behavior change involves an actual recoding of the perception of the stimuli.

Stewart has developed a research program for his doctoral dissertation, which proposes that stimuli representing points along a single psychophysical continuum do not become established in long term memory even with extensive practice. Stewart argues that the inability to build up exact representations of such stimuli in long term memory underlies the remarkable limitation often reported in studies of absolute judgment. It is well known that subjects are unable to transmit more than 3 to 3.5 bits of stimulus information in an absolute judgment situation. This value closely approximates the memory span. Whereas in most memory tasks repetition of the same stimulus set allows subjects to go beyond the memory span, the striking aspect of the absolute judgments are that even after long continued practice subjects still are unable to recognize more than about ten stimuli without error. Stewart's view assumes that the absolute judgment capacities rest upon memory. He further proposes that the rate of forgetting the magnitude of a given stimulus will not be a function of prior practice with that stimulus. This is equivalent to suggesting that no long term memory representation is built up with practice. Such a finding would be remarkably different than what is obtained with other work in memory and would open the very difficult question of why it is that stimuli along a single dimension should be so different. Stewart's experiment uses tones as the stimuli and a linear positioning movement as the response. He can thus observe the variability of the response directly by measuring the variance of the positioning response. His expectation is that the variance of the responses will increase with time in store and interpolated stimuli, but that this rate of change will not be affected by practice.

With unidimensional stimuli the main problem of interest is the relationship between physical and psychological magnitudes. When stimuli begin to differ in more than one dimension qualitative mapping of the external physical space into an internal psychological representation becomes of interest. Attneave has been pursuing this question in an effort to develop an analysis of the structure and function of "cognitive maps" of physical space. In a recent study (Attneave & Olson, 1967) it was shown that the discrimination of line elements tended to be controlled by their orientation in physical space rather than on the retina. A current experiment presents vibrations to the fingertips as stimuli for paired associate learning. In a transfer task the vibrators remain fixed in space but the assignment of fingers to vibrators is changed; subjects are than asked either to give the same response to the same vibrator or the same finger. Initial results indicate that the assocations are predominently to spatial location rather than to the fingers.

These studies show the rather close linkage of the perceptual code to the qualitative and quantitative characteristics of the physical stimulus situation. Of course one would expect these tight links to be reduced as we move away from the immediacy of the perceptual situation toward an increased reliance upon memory.

II. PERFORMANCE AND MEMORY

The theme of this work concerns the analysis of central processing capacity and its relationship to various perceptual, memorial, and effector processes. The underlying assumption is that the central processing mechanisms of the human are limited in their overall capacity.

Many situations require this limited capacity to be shared among tasks. For example, a driver may be talking and simultaneously attending to his driving; or an air traffic controller must attend to many aircraft; or a student might study and watch television. Keele (1967) has developed what is, perhaps, the most complete analysis yet attempted of the ability of humans to time-share between unrelated tasks. This study was completed prior to the initiation of the contract and was recently published. Figure 1 provides a particularly good overview of the findings, though it was not developed in time for inclusion in the published paper. The surface represents the efficiency with which the two tasks can be performed simultaneously. Points lying on the zero plane indicate that performing the two tasks simultaneously requires a time equal to performing each separately. Points above that plane indicate that simultaneous performance is superior to doing each separately, while points below the plane indicate the reverse. The two tasks are a serial reaction time task varying in compatibility and a mental arithmetic task varying in difficulty. One interesting result apparent in the Keele surface is that even the most incompatible reaction time task can be efficiently time shared with relatively routine mental processing.

Recently Keele has used the same serial reaction time task to study the question of degree of transfer between stimulus and response components in successive tasks. With his reaction time task it is possible to control independently the degree of relationship between the stimuli and responses in the successive tasks, while leaving the overall stimulus-response compatibility constant. The results of this study are not yet analyzed, but they should provide a relatively complete description of the role of stimulus and response elements in transfer.

Keele and Ells have broken the question of time sharing down in a more analytic fashion in some experiments which are currently being conducted in the laboratory. These studies concern the ability to overlap individual decisions made to each of two consecutive signals. The rational for the first experiment is as follows: if the decision concerning the response to a signal is made more difficult (i.e., takes a relatively longer time), then the decision required by a second signal arriving shortly after the first should be delayed more than when the first decision is easy. The decision difficulty of the first signal is varied by manipulating the number of lights to which a rapid response has to be made and the spatial relationship (compatibility) between the lights and the response key. The second signal is a visually presented digit which must be rapidly classified as odd or even. The reasoning behind a second but related experiment is slightly different. Suppose the subject must respond to the first signal before he can respond to the second. If the decision to the first signal takes a long time and if the decision of the second signal can be made simultaneously, then it shouldn't matter whether the second decision is hard or easy. In either case the decision to the second signal can occur before the decision to the first is completed. Thus in both cases the subject must wait until the first response is made before he can execute the second response. If, on the other hand, the two decisions cannot be made simultaneously, the time to respond to a difficult second signal will be larger than the time to respond to a easy second signal. In this experiment the first response involves key pressing to lights and the second response involves classifying either two or eight digits into odd or even.

So far only preliminary results from the second experiment have been summarized. These suggest that, separate decisions cannot be made simultaneously. By the time of the next quarterly report, both experiments should be completed, thus allowing a further analysis of time sharing in these relatively simple two response situations.

Though man is limited in his processing capacity, he is extremely flexible in what aspects of the environment he invests this limited capacity. This has been shown very strikingly by two recent masters theses conducted in part under the ARPA grant and both now submitted to the Western Psychological Association for the spring meeting. In one of these, Lewis presented dichotic words to the subject requiring him to shadow the words on one ear and

ignore the words on the other ear. In various conditions he opposed the shadowed words with either synonyms, associates, or irrelevant control words on the opposite ear. He was able to show that the subjects did have longer reaction times to the shadowed word in those cases when the word on the unattended ear opposite it had a similar meaning or was adjacent to it in normal speech. These results suggest that the "unattended word", far from being filtered on a peripheral level, is in fact attended to sufficiently to derive its meaning. This despite the fact that the subject shows little evidence of having stored or really understood the unattended word. To illustrate this last point, Lewis used obscene words in the unattended ear and found that even with these words the subjects were unable to report that there was anything unusual about the material on the unattended ear.

These findings indicate that a certain amount of processing capacity must be invested in even the unattended stimuli. However, for some reason which is as yet unclear, the unattended material does not receive quanitatively sufficient processing capacity to ~~reach memory to~~ be stored on a more permanent basis. Or perhaps, the processing given to it is qualitatively different than that which is apparently necessary for storage.

In a somewhat similar vein, Warren has studied stimultaneous presentation of audio and visual digits. He has shown that the audio digits are better recalled and survive a delay interval more effectively than do the visual digits. He has also shown that the subjects are quite capable of maintaining separation between the auditory and visual digits such that they rarely make confusion errors as to the source of the digit even in series which have mixed within them audio-audio, visual-visual, and audio-visual pairs. By comparing the audio and visual portions of audio-visual lists with pure audio and pure visual stimuli, Warren was able to show that the primary difference between the audio and visual memory codes in this task was not in what happens during storage or retrieval, but was in initial encoding of the stimuli. Warren suggests that the allocation of attention is preempted by the auditory stimulus and it is, therefore, very difficult for the subjects to properly code the visual stimulus for storage.

The visual stimulus in Warren's experiment plays somewhat the same role as the unattended message in the Lewis experiment. However, in Lewis's experiment the instructional emphasis is so heavily placed upon the attended message that the retention of the unattended material is almost completely lost. Perhaps a synthesis of these two experiments will be obtained when Lewis attempts to push his shadowing work into the area of audio-visual presentation. Lewis hopes to be able to show that the material coming in on an unattended modality (as distinguished from an unattended ear) is also processed at a level of meaning. Such a result would be extremely important for the development of information processing theories concerning the level of analysis at which differences in attention are felt.

A central theme current in human performance studies are qualitative differences between memory storage systems. Up until the last several years, almost all the emphasis in short term memory was placed upon the retention of material which is either verbal or which is read-in by the subject in terms of a verbal description. Our laboratory has been concerned with developing operational distinctions between visual, verbal and kinesthetic memory (Posner, 1967a, b).

One of the most interesting types of non-verbal representation is in the form of motor programs. Posner (1967a) has compared visual and kinesthetic codes in various types of motor movements. He found that visually guided movements showed no forgetting with rest and rapid forgetting with control of attention during the retention interval; while non-visually guided movements showed forgetting with rest and no effect of the degree of the attention during the interval. Under the current contract, Keele has conducted experiments following up properties of kinesthetic memory codes. Keele found, in agreement with the earlier data, that kinesthetically guided movements show forgetting even when the subject is allowed to rest for ten seconds between the occurrence of the movement and its reporduction. He showed that control of attention did affect the memory for short motor movements but not for long movements. A re-analysis of the Posner and Konick (1966) data also indicated that there was a difference between long movements and short movements in this regard. Keele has suggested that the difference between long and short movements rests in some additional cue present for short movements which are not present for longer movements. Keele's speculation is that cue may have something to do with the integration of motor outflow information. Keele first presented these findings in a colloquium talk at the Human Performance Center, University of Michigan and they have been incorporated as part of a longer paper to be submitted to the XVIth International Congress of Applied Psychology (Posner & Keele, 1968).

An understanding of the retention of motor programs is inevitably related to conditions under which the original movement was made and under which it is reproduced. At one time psychologists were deeply concerned with understanding of the details of the execution of skilled movements. Many important studies were conducted at the turn of the century. Much of this material has disappeared from the current literature. Keele (1967) has been reviewing this literature and is in the process of preparing an extensive review of the most important findings. The paper includes sections on movement speed and accuracy, attention to feedback, formation of motor programs and reproduction of movements. This paper should make a contribution to the re-establishment of the study of central control of skilled movement as an important discipline within experimental psychology.

Another type of memory code is visual in form. We have developed a reaction time technique which allows us to separate the visual and verbal

components of the memory code for a single letter (Posner & Keele, 1967). The basic idea is to use the difference in reaction time for matching physically identical letters (e.g., AA) and those which have only the same name (e.g., Aa). A series of these studies were presented to the fall meeting of the Psychonomics Society (Posner, Keele & Eichelman, 1967). These studies show that under normal conditions the visual component of the letter decays rapidly (in about 1.5 seconds). The decay function from two studies is shown in Figure 2. This rate of loss can be increased by control of the central processing capacity immediately after presentation of the first letter. The visual information can also be preserved more effectively if conditions direct the attention of the subjects to the visual aspect of the stimulation (visual rehearsal). Most striking are the data which seem to show that subjects are able to generate the visual representation from the name of the letter. Our findings appear to be the first systematic method for studying the functional significance of visual imagery in a situation which allows objective measurement.

Some current studies seek to explore in some detail the conditions under which rehearsal of visual information is possible. The main finding is that the presence of visual noise does not interfere with rehearsal of visual information. While rehearsal can be very efficient within periods of time of 1 - 2 seconds, it does not seem to be easy for subjects to extend the period of the presence of the visual inforamtion longer than for about 2 seconds. We are not sure whether this difficulty in rehearsing for periods of time longer than 2 seconds is primarily due to incentive or whether, in fact, it is a physical property of the visual system. If the latter were the case, it might be related to disappearance with a stopped retinal image and other satiation phenonmena. An abstract (Boies, Posner, & Taylor, 1967) detailing our present results concerning the conditions under which visual rehearsal occurs has been submitted to the Western Psychological Association.

Posner and Taylor have been using the reaction time technique developed in the previous papers to study the effect of the amount of information in store upon visual memory. They use one, two and four letters as the stored array and a single probe letter as the test. The probe letter may be in either the same or a different case than the visual array. The advantage in reaction time of a physical identity match (i.e., the same case) over that of a match based on a name is used as an indication of the presence of visual information in the array. Preliminary data suggests that the rate of loss of visual information is a function of the size of the array, and that visual information is lost very rapidly if the visual array is as high as four letters. It is hoped in the next few months to also look at the role of visual similarity on the rate of loss of visual information. The current plan is to present data from these experiments at a symposium this summer celebrating Donder's classic introduction of the subtractive method into psychology.

Taylor and Posner (1967) have employed the same basic methodology in trying to determine the order in which subjects search the visual and verbal residuals of previous visual stimulation. In this work, arrays of three letters have been used. The subjects were required to search the array in order to make a physical or name match. In one condition Taylor compared searching with an ordered array (A, B, C) with an unordered array (A, N, B). He found that with an ordered array when the probe was in a different case than the stored information, subjects systematically searched stored information in terms of alphabetical order. In all of the other conditions the order of search of the array was primarily based on the spatial location of letters.

It has been reasonably well established that the allocation of central processing capacity to information processing can reduce the retention of information stored in short term memory. The question of how the prevention of rehearsal leads to the loss of information from short term memory has been one of considerable dispute. Recently, Reicher has been conducting experiments which clarify some of the conditions involved in loss of memory under high information processing rates. In one experiment, Reicher has required subjects to shadow letters as rapidly as possible. Following a paradigm introduced into recognition memory by Hebb, Reicher has repeated some of the letters at varying times during the list. He has studied the probability of being correct in shadowing as a function of the number of repetitions of a letter sequence. He finds that this probability increases for repeated letters much more than for unrepeated letters and this occurs even in situations where the subject is unaware that repetition has taken place. This technique confirms Hebb's finding that some information is stored even in cases of extremely high processing load. Moreover this occurs without a specific intention or set to learn.

On the other hand, it is equally clear that the information that is stored in such demanding tasks is not sufficient to allow recall or even completely correct recognition of what has taken place. The theoretical dispute on what leads to the loss of information in the absence of rehearsal was originally seen in the debate between so called interference and decay theories. More recently, theories have been outlined which depend upon incremental and/or decremental processes occurring within the retention interval. One such view is that during the retention interval generalization from the stored stimulus to other competing responses builds up and this leads to errors at recall due to an inability to discriminate the correct alternative. On the other hand, it has also been suggested that the processes during the interval are fundamentally decremental. That is that the role of interference is to destroy traces by intermingling among similar items. Reicher has designed a very interesting experiment which seeks to test these theories. He presents words at very rapid rates which the subjects must shadow. Unknown to the subject is a critical word within the list which he must later

recognize. That critical word may or may not have other rhyming words which are similar to it. There also may be words which rhyme with the alternative to the critical word which will appear later in the recognition test. The preliminary data obtained by Reicher seem to argue for the incremental generalization model as opposed to the fundamentally decremental view. Reicher expects to collect additional information along this line.

III. COGNITIVE PROCESSES

The group working on cognitive processes have been involved in two aspects of analysis of concept learning. One aspect of the work is closely related to perception and concerns learning to identify a new figure as an instance of some previous concept. This type of concept learning has been called pattern recognition or schema learning since it is difficult, if not impossible, to outline the rules which govern the classification. On the other hand, concept studies have more usually been concerned with the identification of rules which relate to specific attributes or dimensions of the stimuli. Sometimes this aspect has been called concept identification.

Posner, Keele and Frost have been conducting a series of experiments which fall into the former category. The first paper of this series (Posner & Keele, 1967) was written before the initiation of the contract and is currently in press. The basic notion of this paper is to investigate the abstraction process which takes place when subjects learn to classify a number of similar instances into the same category. The stimuli are twelve dot patterns which are statistical distortions of three prototypes. (See Example Figure 3) The response is classification into one of three categories based upon the prototypes. The findings suggest that the broader the category in original learning the greater is the ability to recognize new patterns. The experiments also show that the ability to recognize the prototypes is better than other patterns which have the same overall similarity to the learned patterns. This appears to be the first direct confirmation of the Bartlett's notion of abstraction of the central tendency (schema) in the process of learning a common response to dissimilar stimuli.

In order to determine whether or not the abstraction process actually took place during learning or at the time of recognition it was necessary to find conditions where the recognition of the prototype, which had never before been seen, was superior to the patterns which the subjects had actually learned to classify. This would clearly indicate that the recognition of the central tendency did not depend upon mediation by the stored patterns. Posner and Keele have been able to demonstrate this phenomenon in a situation where the subjects waited one week between learning and pattern recognition. Thus it appears that the abstraction takes place during learning and allows a representation of the category in

a form more like the central tendency than like the individual stored patterns. The abstracted information shows no tendency to be lost over a weeks delay, while the information about the individual stored patterns shows a significant decline over a seven day retention interval.

Recently Frost has developed a potent technique for studying the process of abstraction in more detail. Instead of requiring a long initial learning task followed by pattern recognition, Frost has developed a running recognition memory technique which depends upon presenting one dot pattern at a time from a pre-recorded video tape. The subjects are required to say whether each stimulus is "old" or "new", i.e., whether they have seen it previously in the list or not. Frost hopes to use the false-positive rate to the prototype patterns as indicator of the degree to which the central tendency has been abstracted from previous exemplars. This procedure is efficient and should allow a parametric investigation of the effects upon abstraction of such factors as the level of variability and number and distribution of the exemplars.

Hyman and Well have been working on the boundary between abstraction processes of a perceptual nature and situations where subjects consciously combine information from different dimensions. In work completed prior to the contract they showed (Hyman & Well, 1966, 1967) that multidimensional similarity judgments of color patches combined the information from the two varying dimensions (saturation and brightness) according to a Euclidean model, while judgments of stimuli varying in area of a circle and inclination of its radius were better fit by a city block or additive combining rule. They sought to explain these findings in terms of the ease of analysis of the latter stimuli into the component dimension compared to the relative impossibility of such a deliberate analysis of the color patches. When they performed such an analysis for the subject by spatially separating the two dimensions of color they found that the judgments shifted toward an additive combinatorial rule.

Hyman is following up this work during his sabbatical in Italy. His plan is to explore the recognition of new patterns within the space set up by the individual dimensions. Subjects will be taught to classify patterns within a region of the space by a particular response. Hyman will determine the transfer of this response to new pattern located at different positions within the space. Of particular interest will be differences which may appear between the easily analyzed circle stimuli and the difficult to analyze color stimuli.

Anderson has also been interested in comparing relatively perceptual abstraction processes with more conceptual tasks involving hypothesis testing and the learning of rules. He has been comparing stimuli consisting of a series of filled cells. In one set of stimuli the cells are either black or white. In the other set of stimuli they are filled with different geometric designs such as circles, squares, triangles, etc.

Anderson felt that the black and white squares would tend to form perceptual units so that runs of black or white would be taken as processed as single elements. To check on this notion, Johnson and Anderson designed a series of reaction time experiments in which subjects were required to respond whether two strings of cells were the same or different. In agreement with their hypothesis, they found that reaction time was independent of the number of black cells within a sequence of black cells. They conclude that these are processed in parallel, perhaps by some kind of area or brightness estimating process. However, they find that the separate runs of black cells appear to be searched in series. That is for every run of black cells there is an increment in the time to match the two stimuli.

Johnson in his doctoral dissertation is following the coding processes involved in such matching. His basic idea is that subjects will match runs of cells on the basis of brightness when the two strings are present in the perceptual field. However, when a time interval elapses between the presentation of the first string and the matching string, he expects that the subject will have to develop some kind of code which will abstract certain aspects of the location of the runs. Thus Johnson suspects that the major determinant of a "different" reaction time with simultaneous presentation would be the total number of black cells within the string (i.e., brightness). With delay, the major determinant of the reaction time would be the distribution of the runs, since subjects would be unable to code into memory an impression of the overall brightness. Some preliminary findings seem to confirm Johnson's original speculations.

Anderson has compared strings of black and white cells with strings of geometrical forms in concept learning experiments. He hypothesized that in concept learning the black and white stimuli would be treated as perceptual patterns and would, therefore, differ from the geometrical form in the following ways: (a) interference from irrelevant variables would be more pronounced; (b) facilitation by redundancy would be greater; and (c) statements of the concept would more frequently include reference to irrelevant variables. In his experiments the first two results were not obtained, but the third result was obtained. Anderson plans to continue to look for paradigms in which he can separate coding based on relatively simple perceptual schemes as against more complex rule governed coding.

Schaeffer has been pursuing research on the relationship between the learning of rules (conjunctions) and the particular attributes (stimulus dimensions) which are to be combined by those rules. In a recently completed experiment Schaeffer and Wallace (1967) showed that in learning a conjunctive concept the number of redundant attributes that the subjects included in the final conjunction depends upon the particular dimension (size or position) which was relevant to the concept. Their stimuli consisted of six binary dimensions, size, position, number, color, shape, and dottedness. In explaining these results the authors conclude that the information about size is not processed independently of information

about the redundant attributes but the information about position is processed independently. When discriminability of the values along the size dimension is low, more redundant attributes are used. However, this is not the case with position. These experiments suggest that the order and details of the search strategy through the particular attributes have considerable impact upon the type of rule which is formed by the subject. They thus provide some caution against easy acceptance of the view that certain rules are necessarily more difficult than others.

One of the most interesting applications of the analysis of rule-learning is the task of reading. Dawes has shown that many English sentences and whole stories can be analyzed in terms of set relationships (disjunctions, inclusions, etc.) between attributes named in the story. In these studies Dawes was able to show that certain kinds of cognitive distortions systematically occurred in memory which led to errors in answering questions concerning the relationships posited by the story. Keesey has been pursuing this line of research for his doctoral dissertation. Preliminary results have confirmed the analysis which Dawes originally made. Moreover, they suggest that the analysis is even more potent when some of the questions concern relationships which must be inferred from separate sentences of the story rather than being remembered from a given sentence of the story. Keesey calls these "transformation relationships" because they require the subject to infer the relationship indirectly from the material given in the story. He finds that such "transformation relationships" are more difficult to retain and show more complete cognitive distortion than do the relationships which were directly contained within a single sentence. It is hoped that eventually the rule-learning experiments of the type Schaeffer and Wallace have been conducting will provide relevant tools for the analysis of the relationships posited by meaningful discourse.

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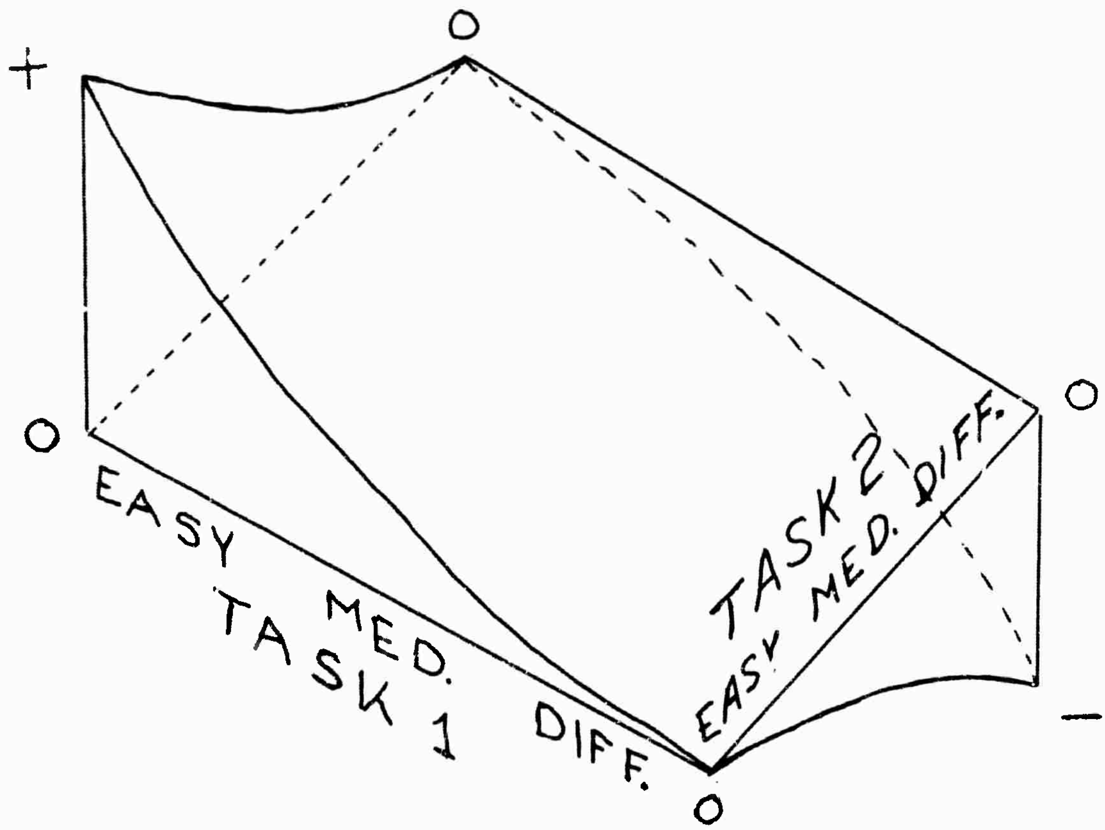
Warren, R. Memory for simultaneous digits. Paper submitted to the Western Psychological Association, 1968.

Figure 1

Keele Divided Attention Surface

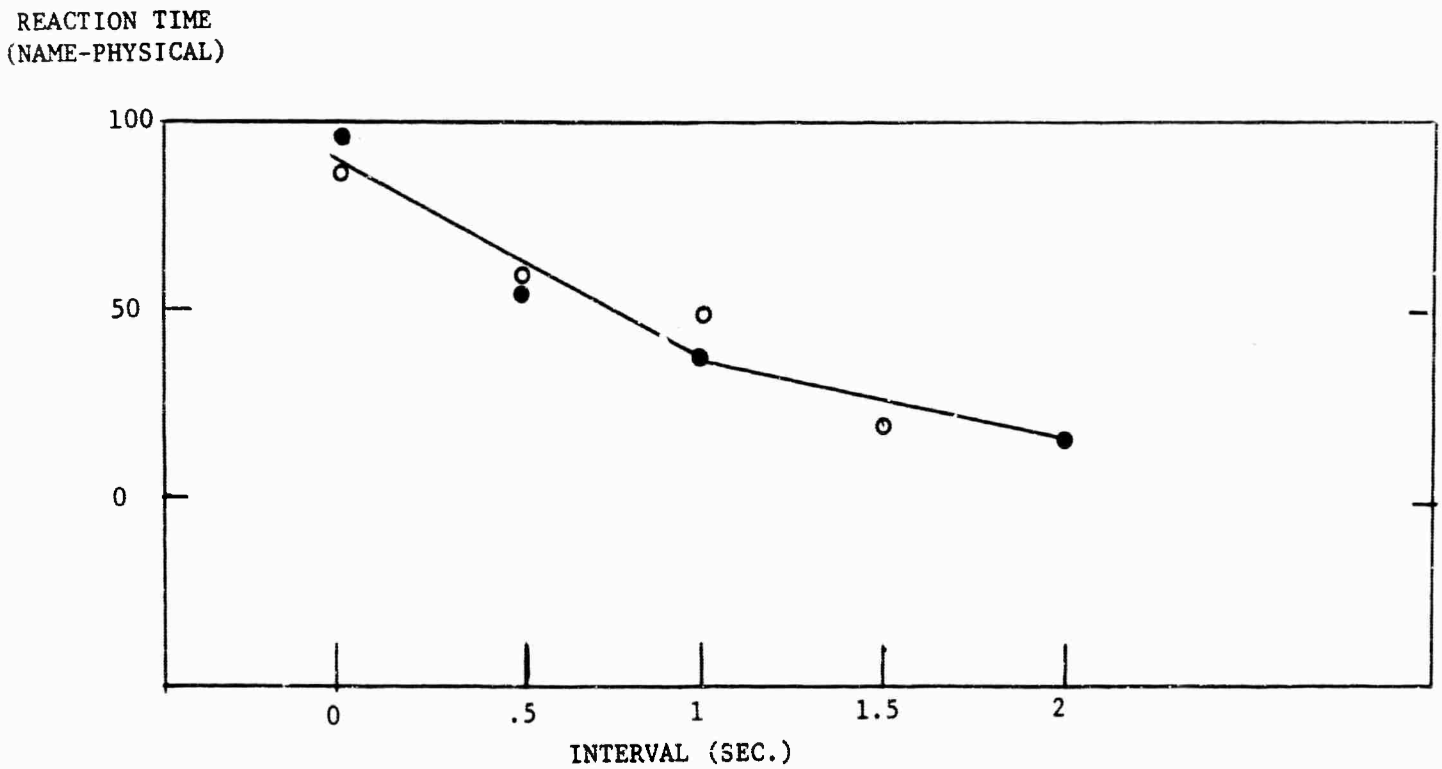


$$\text{Time Sharing Index (TSI)} = \frac{\text{Time}_2 - \text{Delay}_1}{\text{Time}_2}$$

See text for a description of the two tasks and their difficulty.

Figure 2

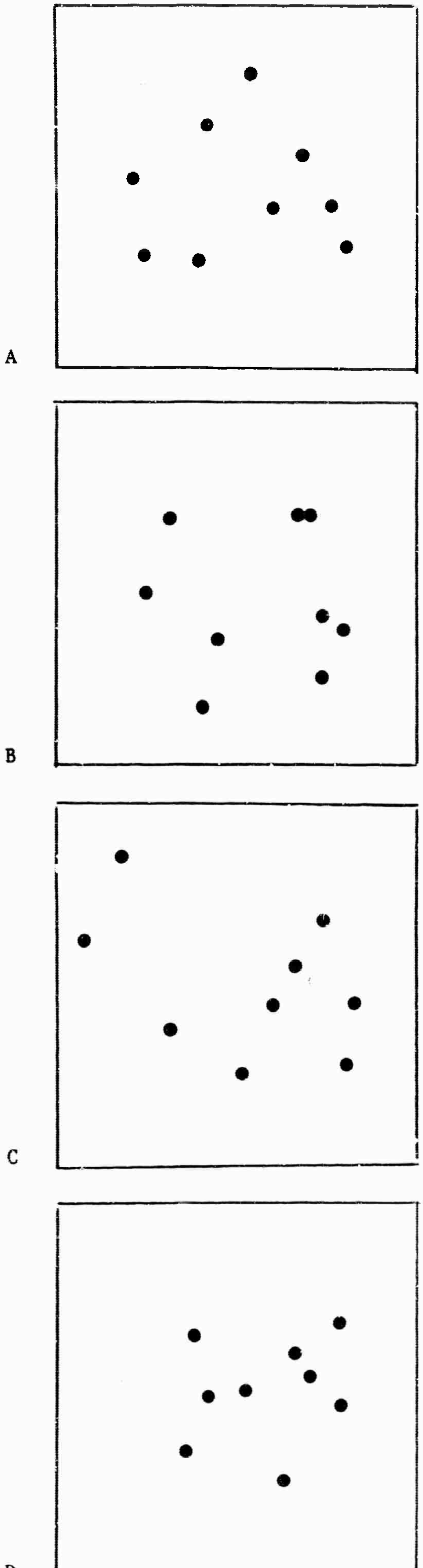
Decay Function for Visual Information From a Single Letter

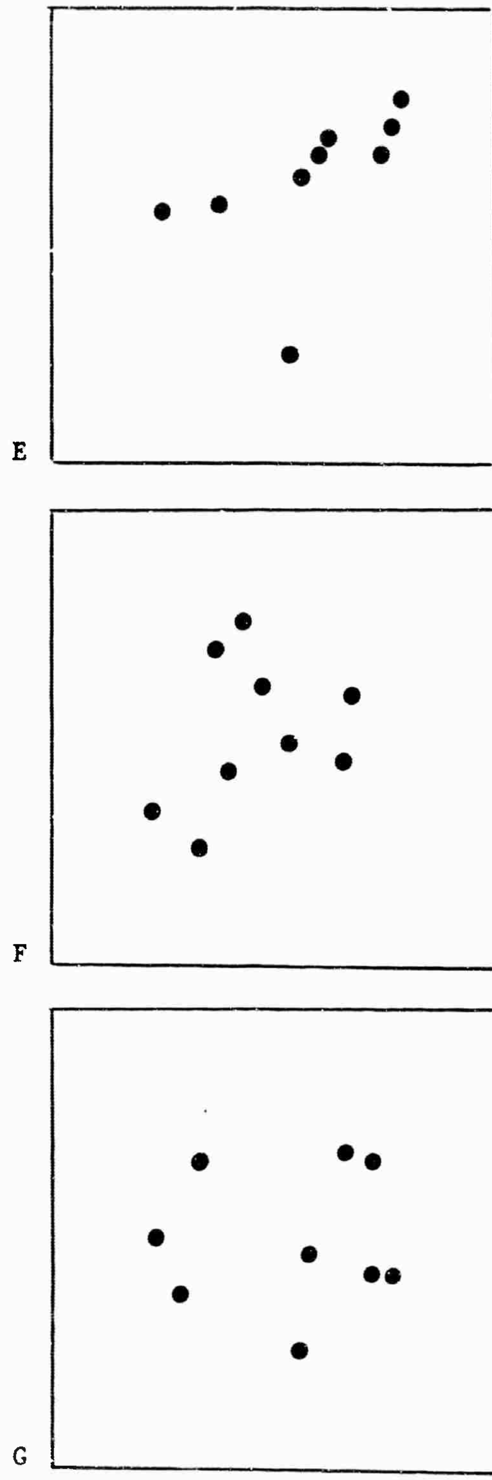


The y axis is difference in reaction time between name and physical matches and the x axis is interval between stimuli in seconds. The solid and open circles represent two different experiments.

Figure 3

The three patterns on the right hand side (E, F, G) are nonsense prototypes. The four patterns on the left hand side (A, B, C, D) are distortions of pattern G.





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13. ABSTRACT

During the first five months of the contract we conducted a number of studies in the areas of perception, attention, memory and cognition. ~~We have begun to work~~ out empirical and theoretical techniques for studying how man allocates his limited processing capacities to various aspects of the environment. ~~We have~~ shown that material which does not reach focal attention can still be related to past experience, but that it shows a serious deficiency in storage. We have studied the process of abstraction from visual to verbal codes and from simple individual stimuli to integrated stimulus compounds. ~~We have~~ shown that the order that man searches and indeed whether or not he incorporates a stimulus dimension into his running estimate of the situation is a function not only of the problem he is to solve, but also of the structure of the environment which furnished him the evidence. They ~~indicate qualifi-~~ cations to the view of man as being a wholly unified system specifiable in terms of an overall processing capacity. They emphasize instead the coexistance of stimultaneous codes in different sensory forms and the flexibility with which codes are used in particular situations.

14. KEY WORDS	LINK A		LINK B		LINK C	
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Cognition						
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Attention						